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Numerical Analysis of Geogrid Reinforcement on the Ultimate Bearing Capacity of Strip Footing Under Eccentric Loads and Determination of Optimum Layout

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ABSTRACT: In this study, the effect of geogrid on the ultimate bearing capacity of strip footing, which was imbedded on sandy soil and under eccentric loads (VM) was investigated by using PLAXIS 2D finite element software. After numerical verification, the effect of parameters, such as the amount of eccentricity, applied vertical load, the number of reinforced layers and layout of the geogrid layers on the ultimate bearing capacity of strip footing was studied. The results of analyzes were presented in the form of dimensionless graphs. Based on the analyses result, the optimum depth of first geogrid layer from foundation (u), the vertical intervals of the layers (h), the number (N) and layout of the geogrid layers have been determined. The results of the analysis show that by adding the geogrid layers, the bearing capacity of footing under the eccentric load increases significantly. The amount of the effectivity is related to the layout of layers and the amount of the eccentricity. In the optimum layout of the layers, the position of geogrid layers depends on the number of layers. Also, the optimum number of layers for obtaining the maximum bearing capacity at eccentric load condition was obtained to be four layers in the present study. The optimum depth for the first, second, third and fourth layers, at the optimal layout, was 0.5, 0.7, 0.3 and 0.9 meters from the base of the footing, respectively.

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1. INTRODUCTION

Today in geotechnical engineering, geosynthetic materials are used to improve soil, including increasing soil bearing capacity. Researchers in this field have tried to estimate the efficiency of the foundations which is exist above the reinforced soil and to develop rational design methods by performing small-scale and large-scale experiments. researchers have also conducted numerical studies and have investigated the parameters affecting the behavior of reinforcements, reinforced soil, and increased bearing capacity of the foundations. Most of the previous studies have assumed vertical loads in the center of the footings, but in practice the loads on the structures and subsequently the loads are with the deviation from footings center (vertical loads with eccentricities). The studies in this area of research are restricted.

In 2008, Saran et al. with Using of a laboratory model, investigated the effects of soil reinforcement with using geogrid layers under eccentric vertical loading and oblique loading on the bearing capacity of strip and square foundations with respect to geogrid number and dimensions [1]. In 2009, El Sawwaf studied the effects of sandy soil reinforcement with force eccentricity on strip foundations with using a numerical and laboratory method. His results show that the use of reinforcements has a significant effect on increasing the bearing capacity rate [2]. In 2013, Ornek with laboratory tests, studied the ultimate bearing capacity of soil with considering of soil density, four different width of foundation and amount of eccentricity of loads. His findings showed that by increasing the central deviation and load angle, the ultimate bearing capacity of sand decreases [3]. Badakhshan and Noorzad in 2015 with experimental study, investigated the effect of eccentricity amount on the behavior of circular foundations located on sandy bedding reinforced with geogrids. They determined the optimum depth of geogrid layers placement as well as the effect of the number of geogrid layers on settlement-load behavior under different eccentricities [4]. The results of past research show that the geogrid reinforcement layout includes the distance of the first reinforcement layer from the foundation (u), the vertical spacing of the reinforcement layers (h), the number of geogrid layers (N), the length of the reinforcement (L) as well as the depth. Reinforcement play an important role in increasing the bearing capacity of foundations, placed on reinforced soil, under eccentric load condition. So far, no study has been performed on the optimum layout of geogrid layers on the bearing capacity of surface foundations under eccentric loads. The present study aims to investigate the reinforcing role of geogrid on the bearing capacity of strip footing under eccentric loads condition (VM (vertical force (V), bending load (M)) with using numerical method and

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find the optimum geogrid layers layout.

2. METHODOLOGY

PLAXIS 2D finite element software was used to simulate the model of geogrid effects on the soil ultimate bearing capacity with eccentric load. The modeling was performed according to the study of Lukidis et al. (2008) [5]. For this purpose, a model with a height of 6 meters and a width of 13 meters was made and a concrete strip footing with a width of one meter and a thickness of 0.5 m was modeled at the ground surface on sandy soil. According to Khing's 1993 studies, the length of the geogrids is assumed to be 6 meters [6]. The ultimate bearing capacity of the footing was obtained for vertical load with different eccentricities.

In order to evaluate the accuracy of modeling in VM condition, the achieved results of numerical model analysis in PLAXIS software have been compared with the results of Lokidis et al. (2008) and the laboratory study of Gottardi and Butterfield (1993). the results of this comparison without using geogrid layers, are shown in Fig. 6.

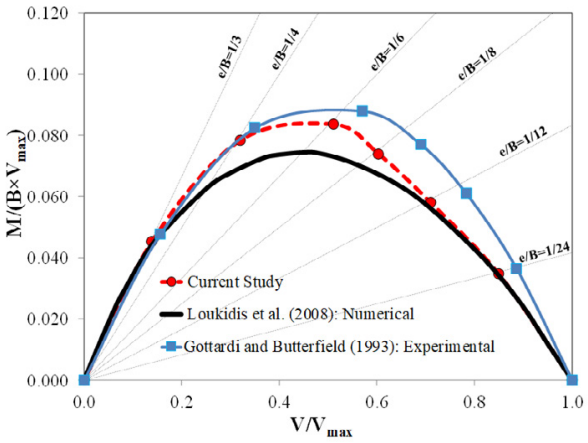

Fig. 1. Comparison of the results of the present study with Lukidis et al. (2008) [5] and Gottardi and Butterfield (1993) [7] in VM loading condition

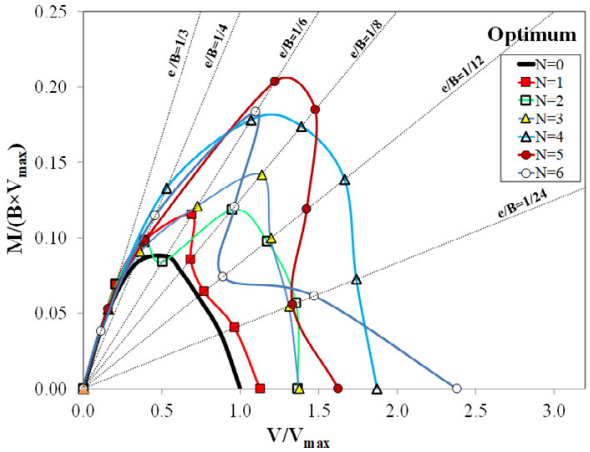

Fig. 2. Optimum values of bearing capacity in VM loading condition for different number of geogrid layer

3. DISCUSSION AND RESULTS

After model verification, each geogrid layer has been installed at the different depth of the soil, so the best depth for layer is the depth that the bearing capacity is the maximum. When the optimum depth of first layer is determined, the second layer is placed above and below the first geogrid layer and the place which gives the maximum amount of ultimate bearing capacity is the optimum depth for second layer. This process has been continued until with increasing of the layers, the changes of ultimate bearing capacity was not significant. Optimum depth of each geogrid layer from strip footing was achieved. Fig. 2 indicates the optimum values of bearing capacity in VM loading condition for different number of geogrid layer. As seen, four layers of the geogrid resulted in the maximum bearing capacity for the strip footing on sandy soil, considered here.

4. CONCLUSION

Using a numerical study, effect of geogrid layers on the bearing capacity of a strip footing under eccentric loading condition was investigated. By applying different layers of geogrid at various level of the bearing soil, the optimum depth and number of layers have been achieved in VM loading condition.

Base on the results, by increasing the number of reinforced layers, the amount of the ultimate bearing capacity increases until the fourth layer. Using the geogrid has great effect on bearing capacity of the footings under eccentric loads. The amounts of 0.5 m, 0.7 m, 0.3 m and 0.9 m are achieved for optimum burial depth of first, second, third and fourth layer of geogrids, respectively.

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